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COMPARATIVE CHARACTERISTICS OF PRODUCTIVENESS OF VARIOUS METHOD--ETC(U)
MAY 77 V I AGAFONOV, Y I BABKIN, D G VDOVIN

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COMPARATIVE CHARACTERISTICS OF PRODUCTIVENESS OF VARIOUS METHODS OF PLAGUE IMMUNIZATION

by

V. I. Agafonov, Ye. I. Babkin, et al.

FOREIGN TECHNOLOGY DIVISION

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М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α	*α*	Nu	Ν ν	
Beta	Β β		Xi	Ξ ξ	
Gamma	Γ γ		Omicron	Ο ο	
Delta	Δ δ		Pi	Π π	
Epsilon	Ε ε	*ϵ*	Rho	Ρ ρ	*ϱ*
Zeta	Ζ ζ		Sigma	Σ σ	*ς*
Eta	Η η		Tau	Τ τ	
Theta	Θ θ	*ϑ*	Upsilon	Υ υ	
Iota	Ι ι		Phi	Φ φ	ϕ
Kappa	Κ ϰ κ	*ϰ*	Chi	Χ χ	
Lambda	Λ λ		Psi	Ψ ψ	
Mu	Μ μ		Omega	Ω ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

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COMPARATIVE CHARACTERISTICS OF PRODUCTIVENESS OF VARIOUS METHODS OF PLAGUE IMMUNIZATION

V. I. Agafonov, ~~E.~~ Ye. I. Babkin, D. G. Vdovin, V. M. Vorobeichikov, A. A. Vorob~~iev~~ yev, Kh. P. Gamleshko, K. G. Gapochko, N. ~~E.~~ Ye. Gefen, V. I. ~~E~~ Yevstigneyev, O. V. Yemel'yanova, Ye. M. Zemskov, O. G. Imamaliyev, I. I. Kamalov, V. V. Kvirikadze, P. A. Kutyrev, O. P. Misnikov, V. P. Pushkarev, D. A. Rozhdestvensky.
Military Medical Academy imeni S. M. Kirov, Leningrad (Submitted 4 May 1972)

In the total system of anti-epidemic measures conducted with the purpose of preventing infectious diseases, a significant place belongs to preventive inoculations. Here, the results of inoculations are determined to a significant degree not only by the effectiveness of the vaccine preparations, but also by the productiveness of the immunization methods being used.

The subcutaneous (syringe) and skin (scarification) immunization methods against plagues which exist at the present time and are officially accepted for practical use are unproductive, they require a large number of qualified medical personnel for their conducting, and they do not ensure vaccination of large contingents of people in a short period.

The searches for methods of mass immunization began relatively long ago, although their wide study and introduction into practice was only recently realized.

The subcutaneous (syringe) method, although it is ~~also~~ characterized by low productiveness, has been a popular immunization method up until now. Subcutaneous inoculations were only permitted

to be done by a doctor, and in unusual circumstances - by an experienced doctor's assistant under the doctor's observation. A specially prepared place is necessary for conducting a subcutaneous vaccination. Inoculations are given with strict observance of the aseptic standards.

The data in the literature (table 1) confirm that the productiveness of the subcutaneous (syringe) method with the work of a ~~crew~~ team of 3-4 men fluctuates from 30 to 50 men per hour. These results are also corroborated by our observations (1970) - with subcutaneous immunization of people with typhoid vaccine with sextanatoxine, a team of 4 men vaccinated 40-50 ~~men~~ people per hour. Higher results, obtained by Verkholomov et al (1958), were explained first of all by the fact that they did not consider the initial time expended for the preparatory measures and, moreover, they had a large number of syringes and needles at their disposal, and therefore the costs for sterilizing the ~~tooling~~ instruments were minimum.

The skin method was even more labor-consuming as compared with the subcutaneous (method). The skin, as well as the subcutaneous, immunization can be conducted only in a specially prepared place with strict observance of aseptic standards; for giving skin inoculations experienced and trained vaccinators are required.

According to the data from the literature, the productiveness of the skin method is still less than the subcutaneous and fluctuates from 10 to 40 men per hour. The time expended for immunizing one person fluctuated from 2 to 8 minutes. During a work day a team can inoculate from 75 to 250 people. The authors ~~conduct~~ present a calculation of the productiveness of one inoculation team without

a more exact definition of its numerical make-up (table 2).

In 1960 during the outbreak of natural smallpox in Moscow, 6,464,865 people were vaccinated in 5 days. This work drew more than 267,000 medical workers and created 11,913 inoculating teams. On the average, each team inoculated about 550 people for the 5 days, i.e. 110 men per day (Lebedinskiy, 1971).

The needleless (jet) method, retaining the basic advantages of the subcutaneous method (strictly controlled individual injection of the preparation with accurate dosing), is distinguished from it by its high productiveness (table 3). The wide practice of mass immunization by the needleless method shows that depending on the type (model) of the injector used and on the specific conditions its productiveness fluctuates from 1000 to 1500 people per hour. The greatest productiveness was recorded with the use of injectors with an electric drive (Malti-Jet) and pneumatic injectors.

The aerosol method is highly productive. Aleksandrov et al (1961) show that they inoculated 800 people per hour with the simultaneous work in two rooms each with a volume of 100 m^3. According to the generalized data of Lebedinskiy (1971), the maximum area used for vaccination by the aerogenic method was 50 m^2. In this room a maximum of 200 people can be inoculated simultaneously (Labezov, 1967). An immunization session with dry dust vaccines, including preparation of the vaccine, its loading in the bin of the instrument, entry and exit of those vaccinated, took 25-30 minutes. Consequently, 400 people can be vaccinated in an hour. A calculation is conducted ~~in~~ for 3 sessions per hour for each aerosol vaccine

(table 4) in conjunction with the curtailment of the immunization session to 5 minutes, which permits vaccination of 600 people in this time (Lebedinskiy, 1971).

From the point of view of productiveness the peroral method has been insufficiently studied, and we have failed to find any literary data on this subject.

The purpose of [~~the present~~] this work was the study of the productiveness of methods of mass immunization (aerogenic, needleless, peroral) in comparison with the classic [methods] (subcutaneous, skin). The study was conducted on a sample of live plague vaccine ~~EB~~ EV; however, the acquired data, in our opinion, can be ~~spread~~ extended to other vaccine preparations, also. The investigations were accomplished with mass systematic immunization of organized collectives of adults.

For a comparison of the productiveness of various methods of vaccination a single method ~~of~~ for its calculation was worked out.

The final evaluation was done according to the formula:

$$K = \frac{x}{tm},$$

where K - coefficient of productiveness; x - number of people inoculated; t - total time - the time necessary for preparing the room, equipment, ~~tooling~~ instruments, and dilution of the vaccine; the intervals connected with the ventilation of the room, entry and exit into ~~to~~ the room of people (aersol method), changing the vials of vaccine (needleless method), periodic treatment of the vaccinators' hands, and, finally, the time for conducting the vaccination itself; this did not include the time connected with organizational questions for ensuring the timely arrival of people for ~~to~~ inoculation; m - is

the make-up of the vaccinating team (with tests of all methods the team consisted of 3 people).

The vaccination by all methods was conducted in individual sessions. Continuous vaccination time meant ~~was realized for~~ the session with peroral, needleless, syringe, and skin immunization methods. Their duration was basically determined by the number of simultaneous arrivals of people for inoculation.

The data which characterize the productiveness of the various immunization methods indicate ~~corroborated~~ (see table 4) ~~the fact~~ that a great effect on the productiveness value was rendered by the initial time expended for preparation for the vaccination. Therefore all immunization sessions for each method were divided into initial and subsequent (repeated). The initial sessions (I) included the additional time necessary for preparing the room and equipment, for sterilization of the instruments, ~~tooling,~~ and dilution of the vaccine. In the subsequent sessions (II) only the time necessary for loading ~~equipping~~ the instruments, diluting the vaccine, and ~~also~~ the intervals for entry and exity from the room of those vaccinated was reflected. The skin and subcutaneous methods in the subsequent sessions also included the time expended for sterilization of needles, syringes, and vaccination styluses ~~points~~ in the vaccination period itself.

The coefficient of productiveness of the subcutaneous method of immunization K fluctuated from 0.17 to 0.27 and averaged 0.24. The throughput capacity of the 3-man team ~~crew~~ was 31-50 people per hour. A ~~The~~ third ~~part~~ of the entire time with the initial sessions of immunization was spent for preparing the room and equipment, and also for sterilization of the syringes and needles. In the subsequent ses-

sions no time for preparing the room was ~~not~~ expended, which led to a substantial increase in productiveness (49-50 people per hour with K - 0.27). Time for direct injection of the vaccine fluctuated from 15 to 22 seconds for each person inoculated, representing an average of 18 seconds. More time was spent for dividing the vials, feeding the vaccine into the syringe ~~needle~~, and preparing it for injection (47-62 s.). On the average, 1 minute was spent for conducting one injection.

The productiveness of the skin method was 19-34 people per hour (average - 28) with K = 0.16. About 1.2-1.5 minutes was spent for each person vaccinated without consideration of additional time. Inoculations by the skin method were done on small groups of people, in different places. Each time, additional time was spent for preparing the room and equipment for vaccination. Therefore, all sessions of immunization were considered as initial (see tbl. 4). The number of injection styluses ~~points~~ was limited. All of this adversely affected the productiveness of the method.

The indicators of productiveness of the subcutaneous (syringe) and skin methods which we obtained coincided with the average indicators given by the other authors (table 5).

With mass subcutaneous immunization with the aid of the BIP-4 the coefficient of productiveness K fluctuated from 2.0 to 4.2 and averaged 2.9 (see tables 4 and 5). We succeeded in vaccinating from 358 to 891 people per hour, which is an average of 517 people. The lower productiveness of the injector which we obtained in comparison with the data of the literature was explained, first of all, by the fact that with both the calculation of the coefficient of productiveness K

and with the calculation of the throughput capacity of the ~~crew~~ team per hour of work we considered the total time spent not only on vaccination, but also on preparation of the room, sterilization of ~~tooling~~ instruments, etc. So, during the initial sessions the throughput capacity was 358-395 people per hour with K = 2.0, and in the subsequent sessions the productiveness increased by almost 2 times and was 424-891 people per hour with K = 3.4-4.2. Of course, with ensurance of a large continuous flow of people the time spent for preparatory operations will not render such a negative influence on the productiveness of the method. If we ~~examine~~ consider only the time which is directly necessary for needleless vaccination, then the throughput capacity of the crew in our investigations reached 1320 people per hour. These data come close to the results obtained by Vorob'yev et al (1967), Agafonov et al (1970), and also ~~near~~ close to the indicators given in the instructions for the BIP-4 instrument (1500 people per hour).

Besides the given data, several structural deficiencies of the BIP-4 injector also affected the decrease in productiveness of the method.

With the aerosol method of immunization we used a room with an area of 43-48 m^2. The productiveness of aerosol immunization with dry (dust) vaccine fluctuated, according to the value of coefficient K, from 1.5 to 3.4 (average K = 2.3), and the throughput capacity was 285-625 people per hour (average 419). The acquired data coincided with the results published earlier (see tables 4 and 5). The productiveness of immunizations with liquid aerogenic vaccine turned out to be higher: ~~according to~~ for value K it fluctuated from 2.9 to 5.7 (average K = 4.5) and ~~by~~ for throughput capacity - from 516 (1st session)

to 1021 people per hour (9th session), representing an average of 817 people per hour.

The fluctuations of productiveness of the aerosol method are also explained by the expenditure of additional time for preparing the room and equipment with the initial vaccination sessions. According to the data of the authors, the productiveness of immunization with dry aerosol vaccine can be increased due to the shortening of ~~exposition~~ exposure from 15 to 5-10 minutes. Moreover, it is known that the productiveness of the aerosol method can be substantially increased with the use of large rooms and several spraying instruments.

Finally, immunization with the aid of tablets was the most productive (see table 4). The coefficient of productiveness K fluctuated within the limits of 4.6-6.8 (average K = 5.2). The throughput capacity of the inoculating team of 3 men was 840-1230 people per hour (average 937). The vaccination technology was simple and ~~included~~ consisted ~~in~~ of the distributions of tablets and observations of their correct intake. The vaccination can be accomplished under any conditions, and qualified medical personnel are not required for its conduct~~ing~~. Immunization was conducted ~~with~~ by sessions on 205-210 people. For forming the people 5 minutes were spent, for explaining the rules ~~of~~ for taking the tablets - 2 minutes, and on the distribution of the tablets - 3 minutes. Thus, preparatory measures took 10 min. The duration of the vaccination process itself, determined by the tablet resolution time, was 5 minutes. The total time expended for one session was 15 min. This was the first test for determining the productiveness of the peroral method of vaccination, and, of course,

it still does not satisfactorily fully characterize it.

Thus, with the comparative evaluation of the various methods of vaccination of people it was shown ~~manifested~~ that the classic subcutaneous and skin methods, for ~~according to~~ their productiveness were many times inferior to the peroral, aerosol, and needleless methods of inoculation, which can be rightfully included in the category of methods of mass immunization of people.

CONCLUSIONS

1. The peroral, aerosol, and needleless methods which were tested with mass vaccination against plague showed much higher (by 10-15 times) productiveness in comparison with the classic subcutaneous and skin methods.

2. Considering the absence of any advantages (reactivity, immunogenicity) of the subcutaneous and skin methods in comparison with mass methods of inoculations, we can recommend the latter ~~last~~ (peroral, aerosol, needleless) for introduction into the anti-epidemic practice of the struggle against plague infections.

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TABLE 1. Productiveness of the subcutaneous syringe method (according to ~~the~~ published data ~~of the literature~~). Key: 1 - author, year; 2 - composition of the team; 3 - number of inoculations per hour; 4 - Labezov; 5 - Verkholomov et al; 6 - Lebedinskiy (1971) (according to the data ~~on~~ in the instructions); 7 - men; 8 - the authors conducted simultaneous immunization with the polyvaccine of the NIISI [Scientific Research and Testing Sanitation Institute] and with the smallpox vaccine.

(1) Автор, год	(2) Состав бригады	(3) Число привитых за час
(4) Лабезов (1967)	3 (7) человека	50—60
(5) Верхоломов и соавт. (1958)*	5 человек	80—100
(6) Лебединский (1971) (по данным инструкции)		30—60

(8) * Авторы проводили одновременную иммунизацию поливакциной НИИСИ и оспоаакциной.

TABLE 2. Productiveness of the skin (scarification) method of immunization (according to ~~the~~ published data ~~of the literature~~). Key: 1 - author, year; 2 - Korobkova; 3 - Nikolayevskiy; 4 - Lebedinskiy; 5 - and coauthors; 6 - time for one inoculation (in minutes); 7 - number of inoculations per hour; 8 - number of inoculations in a day of work.

(1) Автор, год	(6) Время на одного прививаемого (в минутах)	(7) Число привитых за час	(8) Число привитых за день работы
(2) Коробкова (1956) . . .	5—8	10—12	
(3) Николаевский (1969) . . .			До 250
(4) Лебединский (1971) . . .	2	30	110
Gelfand (1966)			75—200
Fredeniksen (5) и соавт. (1959) . . .			75—200

TABLE 3. Productiveness of the needleless (jet) method of immunization (according to ~~the~~ published data ~~of the literature~~). Key: 1 - author; 2 - year, instrument model; 3 - number of inoculations per hour; 4 - Belyakov et al; 5 - Vorob'yev et al; 6 - Nikolayevskiy; 7 - Agafonov et al; 8 - Instructions ~~to~~ for the BIP-4; 9 - et al; 10 - 1964, first test model of the Soviet injector; 11 - BIP-4; 12 - Ped-o-Jet; 13 - BIP-4; 14 - BIP-4 - needleless pneumatic injector.

Автор 1	Год, образец прибора 2	Число привитых за час 3
4 Беляков и соавт.	1964, первый опытный образец 10 отечественного инъектора	600
5 Воробьев и соавт.	БИП-4 [1], 1967 11	1200—1500
6 Николаевский	Пед-О-Джет, 1969 12	1000
7 Агафонов и соавт.	БИП-4, 1970 13	1500
8 Инструкция к БИП-4		1500
Hingson и соавт. 9	1963	1000—1500
Benherf и соавт. 9	1971	1000—1500

[1] БИП-4 — безыгольный инъектор пневматический. 14

TABLE 4. Characteristics of productiveness of various immunization methods. Key: 1 - Immunization method; 2 - sequence of sessions; 3 - number of sessions; 4 - number of inoculations per session; 5 - average time for one session (in minutes); 6 - preparatory measures; 7 - vaccinations; 8 - total working time per session; 9 - number of inoculations per hour; 10 - productiveness; 11 - subcutaneous (syringe); 12 - skin (scarification); 13 - needleless (BIP-4); 14 - dry vaccine; 15 - liquid vaccine; 16 - aerogenic; 17 - peroral (tablets); 18 - initial; 19 - subsequent; 20 - ~~entire~~ Total.

Table 4.

Метод иммунизации (1)	Очередность сеансов (2)	Число сеансов (3)	Число привитых за сеанс (4)	(5) Среднее время за 1 сеанс (в мин.): подготовительные мероприятия (6)	вакцинация (7)	общее рабочее время за сеанс (8)	Число привитых за час (9)	Производительность $K=\frac{z}{tm}$ (10)
Подкожный (шприцевый) (11)	Первичные (18)	3	100—220	60—100	135—210	195—300	31—43	0,17—0,24
	Последующие (19)	2	180—200	40	180—200	220—240	49—50	0,27
	Всего (20)	5	900			1255	43	0,24
Накожный (скарификационный) (12)	Первичные (18)	8	32—196	55—90	45—260	100—340	19—34	0,11—0,18
	Всего (20)	8	813			1698	28	0,16
Безыгольный (БИП-4) (13)	Первичные (18)	2	508—564	52,6—59,5	26—32,4	85—85,5	358—395	2,0—2,1
	Последующие (19)	4	170—462	5,5—10,0	10—29	15,5—39	424—891	3,4—4,2
	Всего (20)	6	2401			278	517	2,9
(16) Аэрогенный: сухая вакцина (14)	Первичные (18)	2	140—204	14,5—17,0	15	29,5—32	285—385	1,5—2,1
	Последующие (19)	3	158—250	6,5—8,0	15	21,5—24	437—625	2,3—3,4
	Всего (20)	5	912			129	419	2,3
жидкая вакцина (15)	Первичные (18)	1	182	14,5	5	19,5	516	2,9
	Последующие (19)	5	158—223	7,0—8,3	5	12,0—13,1	790—1021	4,9—5,7
	Всего (20)	6	1112			81,6	817	4,5
Пероральный (таблетки) (17)	Последующие (19)	3	205—210	5,0—10,0	5	10—15	840—1230	4,6—6,8
	Всего (20)	3	625			40	937	5,2

TABLE 5. Composite data on the productiveness of various immunization methods. Key: 1 - productiveness (in people per hour) with various immunization methods; 2 - subcutaneous; 3 - skin; 4 - needleless; 5 - aerogenic; 6 - dry vaccine; 7 - liquid vaccine; 8 - peroral; 9 - composite published ~~literature~~ data; 10 - in-house data; 11 - average.

	(1) Производительность (в чел/час) при разных методах иммунизации					
	(2) подкож-ный	(3) накож-ный	(4) безыгольный	(5) аэрозольный		(8) пероральный
				(6) сухая вакцина	(7) жидкая вакцина	
(9) Сводные литературные данные	30—60	15—40	1000—1500	400	600	
(10) Собственные данные	31—50	19—34	358—891	285—625	516—1021	840—1230
(11) Средние	43	28	517	419	817	937

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C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C557	USAIIC	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	ERDA	1
P055	CIA/CRS/ADD/SD	1
NAVORDSTA (50L)		1
NAVWPNSCEN (Code 121)		1
NASA/KSI		1
[redacted]		[redacted]
AFIT/LD		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/ RDXTR-W	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	ETID	3
	NIA/PHS	1
	NICD	5